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APPLICATION OF QUEUING THEORY TO WOMEN'S ICC WORLD T20 CRICKET

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Abstract: This paper applies queuing theory to women's ICC world T20 cricket matches. In women's T20 match, two opening batswomen open the innings from which one can find the service rate and the arrival rate for the pitch. Other batswomen are waiting in the dressing room for their bating. We want to determine the probability of winning and losing a women's T20 match. We also seek to determine the probability of winning by first innings and second innings in a women's T20 match.

Keywords and Phrases: Queue, Queuing theory, women's T20 match, batswomen.
2010 Mathematics Subject Classification: 60K25, 60K30.

1. Introduction

Women's T20 cricket is the new emerging format in women's cricket. The rules of T20 game are the same for both men and women. The first T20 international match was held in August 2004 between England & New Zealand women's cricket Teams, six months before the first T20 international match was played between two men's teams. A women's Twenty 20 international (WT20) is a twenty over's per-side cricket match played in a maximum of 150 minutes between two of the top 10 ranked countries of the International Cricket Council (ICC) in terms of women's cricket. The ICC women's world Twenty20 was first held in 2009.

The next ICC women's world Twenty20 will be held in 2020 in Australia in which top 10 women's teams will feature.

In women's T20 match, two opening batswomen open the innings in each innings. This opening pair of batswomen is being served by a single server i.e cricket pitch. The pair of batswomen is considered as a customer. The other batswomen are waiting in a dressing room for their batting which are considered as waiting customers. In this queuing situation, the service time is found from the time period for which the opening pair of batswomen is playing. We can derive service rate from the service time. When the wicket falls, the new batswomen arrives at the pitch at the same time. Hence, the arrival time of the waiting customers is same as service time. The service time follows the Poisson distribution and so the arrival time follows the Poisson distribution. Thus, we apply the M/M/1 queuing model with finite capacity to the women's T20 match.

2. $M/M/1$ Queuing Model with finite Capacity

This model represents the queuing situation in which the system can accommodate only a finite number N of customers.

In the case of T20 match, the finite number of customers is $N = 10$ in each innings. So the maximum queue length is $N - 1$.

In this model, when the number of customers is reached to N, then no other customers are allowed in the system. Therefore, for this model

$$\mu_n = \mu, \qquad n = 0, 1, 2, 3, ...$$

and

$$\lambda_n = \begin{cases} \lambda, & \text{for} \quad n = 0, 1, 2, ..., N-1 \\ 0, & \text{for} \quad n = N, N+1, ... \end{cases}$$

Taking $\rho = \frac{\lambda}{\mu}$, the probability of n customers in the system is

$$p_n = \begin{cases} \rho^n p_0 & \text{for} \quad n \leq N \\ 0, & \text{for} \quad n > N \end{cases}$$

As the total probability is always equal to 1, we have

$$\sum_{n=0}^{N} p_n = 1$$

$$p_0(1 + \rho + \rho^2 + ... + \rho^N) = 1$$

$$p_0 = \frac{1}{1 + \rho + \rho^2 + ... + \rho^N}$$

$$= \frac{1}{\frac{1-\rho^{N+1}}{1-\rho}}$$

Therefore, $p_0 = \frac{1-\rho}{1-\rho^{N+1}}$, where $\rho \neq 1$. and

$$\begin{aligned} p_0 &= (1+1+...+1)_{N+1 \quad times} = 1 \\ p_0(1+N) &= 1 \\ \Rightarrow p_0 &= \frac{1}{N+1}, \quad \text{where} \quad \rho = 1. \end{aligned}$$

Thus,

$$p_n = \begin{cases} \frac{(1-\rho)\rho^n}{1-\rho^{N+1}}, & \text{where} \quad \rho \neq 1 \\ \frac{1}{N+1}, & \text{where} \quad \rho = 1 \end{cases} \quad \text{for} \quad n = 0, 1, 2, ..., N$$

3. Calculation of Probabilities in Women's T20 Match

We seek to find the probability of winning by first innings in a women's T20 match. Further we want to find the probability of winning by second innings. The probability of winning by first innings and second innings in a women's T20 match depends on the Toss at the start of the match. The coin is tossed to decide which team will bat first. It also decides which team will bat second. Suppose W_1 be the event that the women's team batting first and W_2 be the event that the women's team batting second.
Therefore

$$p(W_1) = p(W_2) = \frac{1}{2}.$$

Let I be the event that the first innings is finished irrespective of the number of wickets falling in the innings.
So,

$$\begin{aligned} p(I) &= p(n \leq 10 \ \text{ in the first inning}) \\ &= \frac{1}{11} + \frac{1}{11} + ... + \frac{1}{11}(11 \text{ times}) \end{aligned}$$

Therefore,

$$p(I) = 1.$$

Next suppose I_1 be the event that the women's team batting first win and I_2 be the event that the women's team batting second win. Then the probability of I_1

is calculated as

$$\begin{aligned} p(I_1) &= p(W_1)p(I) + p(W_2)p(n = 10 \text{ in the second inning}) \\ &= \frac{1}{2}(1) + \frac{1}{2}\left(\frac{1}{11}\right) \\ &= \frac{1}{2} + \frac{1}{22} \\ &= \frac{12}{22} \end{aligned}$$

Therefore $p(I_1) \approx 0.55$.

The probability of I_2 is calculated by

$$\begin{aligned} p(I_2) &= p(W_2) \;\; p(n \leq 9 \text{ in the second inning}) \\ &= \frac{1}{2}\left(\frac{1}{11} + \frac{1}{11} + ... + \frac{1}{11}\right) \quad (10 \text{ times}) \\ &= \frac{1}{2}\left(\frac{10}{11}\right) \\ &= \frac{10}{22} \end{aligned}$$

Therefore $p(I_2) \approx 0.45$

The Total probability is

$$p(I_1) + p(I_2) = \frac{12}{22} + \frac{10}{22} = 1.$$

This discussion concludes that out of 22 women's T20 matches, 12 matches are won by the women's team batting first and 10 matches are won by the women's team batting second. In other words, out of 100 women's T20 matches, 55 matches are won by the women's team batting first & 45 matches are won by the women's team batting second. We can verify these probabilities through the actual observation of women's T20 matches in the ICC Women's T20 World Cups in the years 2016, 2018 and 2020.

4. Actual observation

We consider all the matches played during the ICC Women's T20 World Cups in the years 2016, 2018 and 2020. We write the results of all the matches in the tabular form as follows:

ICC Women's T20 World Cup 2016

Match Sr. No.	1st Inn. Win	2nd Inn. Win	Match Sr. No.	1st Inn. Win	2nd Inn. Win
1	W	L	13	L	W
2	L	W	14	L	W
3	W	L	15	L	W
4	W	L	16	L	W
5	W	L	17	L	W
6	L	W	18	W	L
7	L	W	19	W	L
8	W	L	20	W	L
9	W	L	21	W	L
10	L	W	22	W	L
11	L	W	23	L	W
12	W	L	Total:	12	11

- W means Win, L means Lost

ICC Women's T20 World Cup 2018

Match Sr. No.	1st Inn. Win	2nd Inn. Win	Match Sr. No.	1st Inn. Win	2nd Inn. Win
1	W	L	13	W	L
2	W	L	14	W	L
3	W	L	15	L	W
4	NR		16	W	L
5	L	W	17	W	L
6	L	W	18	L	W
7	L	W	19	L	W
8	L	W	20	W	L
9	W	L	21	W	L
10	W	L	22	L	W
11	W	L	23	L	W
12	W	L	Total:	13	09

- W means Win, L means Lost, NR means No Result

ICC Women's T20 World Cup 2020

Match Sr. No.	1st Inn. Win	2nd Inn. Win	Match Sr. No.	1st Inn. Win	2nd Inn. Win
1	W	L	13	W	L
2	L	W	14	L	W
3	L	W	15	W	L
4	L	W	16	W	L
5	L	W	17	L	W
6	W	L	18	W	L
7	W	L	19	NR	
8	L	W	20	NR	
9	W	L	21	NR	
10	W	L	22	W	L
11	W	L	23	W	L
12	W	L	Total:	13	07

- W means Win, L means Lost, NR means No Result

The above tables indicate that during the ICC Women's T20 World Cup 2018, out of 23 women's T20 matches 13 matches had been won by women's team batting first and 09 matches had been won by women's team batting second. If we combine all the matches during ICC Women's T20 World Cups in three years 2016, 2018 and 2020 then also the calculated probabilities are closer to the actual probabilities.

In all, out of 65 women's T20 matches 38 matches had been won by women's team batting first and 27 matches had been won by women's team batting second. So, the probability of winning by first inning is $\frac{38}{65} \approx 0.58$ and the probability of winning by second inning is $\frac{27}{65} \approx 0.42$.

5. Conclusion

This paper concludes that out of 100 women's T20 matches, 55 matches are won by the women's team batting first and 45 matches are won by the women's team batting second in the women's T20 cricket. In addition, these probabilities are verified with the actual probabilities during the ICC Women's T20 World Cups in the years 2016, 2018 and 2020. This conclusion indicates that the probability of winning by first inning remains more than the probability of winning by second inning.

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